California Environmental Protection Agency

Air Resources Board

TEST PLAN FOR EVALUATION OF EVAPORATIVE AND EXHAUST EMISSIONS AND CONTROL TECHNOLOGY FOR OFF-HIGHWAY RECREATIONAL VEHICLES (OHRV)

Engineering Development and Testing Section
Stationary Source Testing Branch
Monitoring and Laboratory Division

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I. Background

Evaporative emissions from OHRVs are a major source of hydrocarbon emissions in California. OHRVs include off-road motorcycles, all terrain vehicles (ATVs), snowmobiles, and other specialty vehicles. Evaporative emissions from these categories can be broken down into three distinct sources:

- Permeation emissions through the fuel tank and fuel hose
- Vented emissions from the fuel tank
- Emissions from the carburetor and leaking connections

In 2002 the U.S. EPA adopted an OHRV permeation standard that is set to be implemented in 2008. The reductions from the U.S. EPA regulation are limited because the regulation only controls permeation emissions. The ARB is developing a rule that will control vented, carburetor, and running loss emissions as well as further control permeation emissions. Initial estimates predict that this ARB regulation can be up to 80 percent effective.

The current emissions inventory does not reflect actual emissions in California. ARB will re-evaluate the emissions factors, OHRVs usage, and OHRVs population to account for this discrepancy.

II. Plan Overview

Inventory Development

The current ARB emissions inventory is based on an old vehicle population and outdated emissions factors. The emissions inventory is calculated by combining usage, population, and emissions factors. The first step in developing a new emissions inventory is to update usage data for off-road motor cycles, ATVs, and snowmobiles. Usage data includes where, when, and how vehicles are being used and stored. ARB will develop new emissions factors by testing in-use and new OHRVs. A new population has already been developed.

Control Technology Testing

To determine the efficiency of evaporative emissions controls, OHRVs will be progressively fitted and tested with emissions control technology. Emission factors that are generated with the retrofitted technology will be used to predict reductions. An important part of the emissions control technology evaluation is a safety and feasibility study. The OHRVs that are retrofitted with emissions control technology will be evaluated in an in-use safety and feasibility study.

Exhaust Emissions study

Exhaust emissions will be measured to quantify potential advantages of improved fuel management systems. ARB is quantifying exhaust emissions reductions because high efficiency catalytic converters can easily be added to fuel injected OHRVs. Exhaust emissions will be measured from unmodified vehicles and then again from OHRVs with fuel injection and high efficiency catalysts. The feasibility and safety study will include evaluation of the exhaust emissions control technology.

III. Test Plan

Activity and Usage

Operation

To determine OHRVs usage, information from available studies will be used. ARB will generate any additional data that is needed for the OHRV program. If required OHRVs usage data will be generated by equipping representative in-use OHRVs with data loggers. The data loggers will record the number of times the OHRVs starts and stops, and the total hours of operated in a given period of time.

Storage

How OHRVs are stored has a large effect on evaporative emissions. If sufficient data is not available end users will be surveyed to determine:

- How long OHRVs are stored
- How OHRVs are prepared for storage
- Where OHRVs are stored
- What the fuel level is during storage
- What type of fuel is used in OHRVs
- On average how many times per riding day their off highway motorcycle is tipped over

OHRVs Design

OHRVs tested as in-use will represent popular models sold in a specific age group. Variations in design that will affect evaporative emissions will be considered.

Inventory Development

Preliminary Equipment testing

Background, vented, and permeation emissions will be evaluated for both the Honda 450X dirt bike and the Polaris Sportsman 500 ATV. Diurnal emissions will be measured over a 65℉-105℉ temperature prof ile using California Phase III RFG pump fuel unless specified otherwise. Background emissions will be measured on an OHRV as it is received from the dealer (without fuel in the fuel system). Vented emissions will be measured with the fuel tank half full but without allowing gas into the carburetor. Permeation emissions will be measured by allowing the fuel to soak in the fuel tank and lines for 30 days and re-tested. By evaluating each mode of evaporative emissions consecutively ARB will know where emissions are coming from.

Baseline Emissions

Baseline emissions will include measuring the diurnal, hot soak, running loss, carburetor spillage, and some exhaust emissions testing for in-use and new OHRVs. See Appendix A for a complete list of vehicles that will be used for inventory development and Appendix D for diurnal temperature profiles. The emissions data will be used to help develop the emissions inventory as well as serve as a baseline value for OHRVs control technology evaluation.

Carburetor Spillage Emissions for Off Highway Motorcycles

At extreme angles such as when an Off Highway Motorcycle (OHMC) is tipped over, the carburetor can leak. Leaks from the carburetor do not fall into any of the existing emissions categories; therefore this will be considered a new source of emissions. The emissions inventory for this category will be calculated by multiplying the following values:

Mass of emissions per tip X tips per trip X trips per year X population

ARB will quantify the emissions factors using the following procedure.

- The vent lines from the carburetor will be connected to a reservoir.
- The OHMC will be tilted until the carburetor begins to leak, this angle will be recorded.
- The carburetor spillage emissions from setting the OHMC on each side will be evaluated separately.
- The OHMC will be set on its side for 60 +/-10 seconds and then lifted back up.
- The actual time the OHMC is tipped past the angle where spillage begins will be recorded.
- The hydrocarbon emissions will be measured as weight gain from the reservoir.

Predictive Model Testing

An ethanol fuel study will be conducted to determine the effect of ethanol on evaporative emissions. For a complete list of tests and equipment included in the ethanol fuel study see Appendix B.

Control Technology Testing

Only one piece of equipment from each category will be tested with control technology because of the cost and complexity of retrofitting and testing. Of the new OHRVs the Honda CRF 450X off road motorcycle, and Polaris Sportsman 500 ATVs, will be evaluated with control technologies. See Appendix C table 8 for a list of testing to be conducted for control technology evaluation. At this time snowmobiles are not operated during ozone non-attainment days; therefore, snowmobiles will not be evaluated at this time.

Each type of control technology will be tested by progressively adding more control technology, and quantifying the emissions reductions as the technology is added.

Technology will be added in the following order:

1. Low permeation fuel tank and fuel line
2. Passively purged carbon canister
3. Fuel injection and an actively purged carbon canister
4. Catalytic converter

The evaporative emissions data generated will be used to help develop an inventory as well as to set evaporative standards for the current regulatory initiative. The exhaust emissions data will be used to support a separate exhaust emissions rulemaking at an undetermined time.

Running Loss Emissions

ARB will evaluate running loss emissions for OHRVs. The load profile for the equipment will be a modified version of the Urban Dynamometer Driving Schedule (UDDS). A running loss emissions comparison study will be conducted where an OHRV with a combined rider and vehicle weight of over 700 lbs will be tested on both the UDDS cycle and the modified 3 step UDDS test cycle defined below. The results will be used to develop a correction factor for the emissions inventory.

The load profile will be a 3 section stepped load profile where the load values are averages of the power requirement calculated from the UDDS. The three sections will be:

1. Average from the initial 190 seconds
2. Average for seconds 191 to 310
3. Average for seconds 310 seconds to the end

A cooling fan will be used to replicate load profile wind speeds.

Engine Speed

Engine speed for testing will be determined for each vehicle separately. The chosen engine speed will be the lowest speed above an idle where the

engine can smoothly handle the loads placed on it during the running loss test.

See Appendix F for the running loss test procedure.

In-use Durability Testing

An in-use durability study will be conducted on the off road motorcycle and ATV after all the emissions control technology has been implemented and tested. The durability testing will help define customer acceptance, real world durability, and ride ability. OHRVs durability will be evaluated over 100 hours of operation. The first 70 hours of operation will be conducted on a dynamometer. During the last 30 hours of durability testing the OHRVs will be operated in the field. During the dynamometer and field durability testing, control technology safety will be evaluated.

IV. Safety Study

During the safety evaluation, industry representatives from Consumer Products Safety Commissions (CPSC) (pending), California State Fire Marshal, and American Motorcycle Association (AMA) will evaluate the safety of the OHRVs as a whole and specifically the catalytic converter and the carbon canister. The following is a list of safety concerns and how they will be evaluated:

Issue: Exhaust gas and component temperature increases from catalytic converters.

Evaluation: Exhaust gas and component temperatures will be measured while the OHRVs is on the dynamometer before and after the OHRVs is retrofitted.

Issue: Exothermic reaction during carbon canister loading.

Evaluation: Virgin carbon will be loaded at the fastest reasonable loading rate while the internal temperature is monitored. This rate is assumed to be the rate of loading while the fuel tank is being filled.

Benefit: Reduction of hydrocarbons being emitted into confined spaces.

Evaluation: During SHED testing the reduction of hydrocarbons being released into a confined space during storage will be quantified.

These laboratory tests should quantify the safety concerns. To evaluate the safety of OHRVs in a real world setting industry representatives will be invited to evaluate the OHRVs in the field during the 30 hour field testing. Industry representatives will have access to the laboratory safety results.

V. Quality Assurance/Quality Control

Testing will be conducted in compliance with the procedures documented in Chapter 40, Part 86, Section 86.107-90 and 96 of the Code of Federal Regulations, and the California Evaporative Emission Standards and Test Procedures for 1978-2000 Model Motor Vehicles. The engineer conducting the testing will validate quality assurance/quality control data for background, recovery and retention checks to ensure that it meets the requirements of 40 CFR Part 86. In addition all fuels used for testing will be evaluated by ARB's Southern Laboratory Branch to ensure they meet CAR and SAE specifications.

SHED temperature data is collected on a minute by minute basis. The engineer conducting the testing will watch the temperature in order to identify temperature data that is operating outside of the given parameters. This temperature data will be flagged by the engineer. The engineer must then determine if the flagged data should be accepted or rejected.

Appendix A – Inventory Testing

All inventory tests will be conducted with California Summertime Pump Fuel (RFG 3).

Table 1

ATVs Inventory testing

All Terrain Vehicles (ATVs)		Baseline and Inventory Emissions Testing				
Model #	HP range	Number of Tests	Running Loss	Hot Soak	Diurnal	Exhaust
New ATVs 1	0-15	1	x	x	x	
New ATVs 2	15-25	1	x	x	x	x
Polaris Sportsman 500	25-50	See Table 6	See Table 6	See Table 6	See Table 6	See Table 6
Used ATVs 1	0-15	1	X	x	x	
Used ATVs 2		1	X	x	x	
Used ATVs 3	15-25	1	X	x	x	
Used ATVs 4		2	X	x	x	
Used ATVs 5	25-50	1	X	x	x	
Used ATVs 6		1	X	x	x	

Number of tests: 9

Table 2

Off Highway Motorcycle Inventory Emissions Testing

Off Highway Motor Cycle (OHMC)		Baseline and Inventory Emissions Testing				
Model #	HP range	Number of Tests	Running Loss	Hot Soak	Diurnal	Exhaust
New OHMC 1	0-15	1	X	x	x	
New OHMC 2	15-25	1	X	x	x	
New OHMC 3	25-50	1	X	x	x	x
Honda CRF 450X	50-120	See Table 6	See Table 6	See Table 6	See Table 6	See Table 6
Used OHMC 1	0-15	1	X	x	x	
Used OHMC 2		1	X	x	x	
Used OHMC 3	15-25	1	X	x	x	
Used OHMC 4		2	X	x	x	
Used OHMC 5	25-50	1	X	x	x	
Used OHMC 6		1	X	x	x	
Used OHMC 7	50-120	1	X	x	x	
Used OHMC 8		1	X	x	x	

Number of tests: 12

Table 3

Deterioration Rate Emissions Testing – Inventory

Deterioration Rate		Deterioration rate Emissions Testing				
Model #	HP range	Number of Tests	Running Loss	Hot Soak	Diurnal	Exhaust
New ATVs 2 after 1 year	15-25	1	X	x	X	x
New OHMC 3 after 1 year	25-50	1	X	x	X	x

Number of tests: 2

Appendix B – Ethanol Testing for the Predictive Model

Table 4
Ethanol Testing for Predictive Model - Off Highway Motor Cycles

Off Highway Motor Cycles				Ethanol Testing for Predictive Model		
Equipment	HP Range	Temp Profile	Ethanol content	Fuel	Hot soak + Diurnal	Running Loss
New Yamaha 250 Dirt Bike	15-25	65-105 summer	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1
Used Off Highway Motor Cycle	25-50	65-105 summer	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1
		47-66 winter	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1

Number of tests: 9

Table 5
Ethanol Testing for Predictive Model – ATVs

ATVs				Ethanol Testing for Predictive Model		
Equipment	HP Range	Temp Profile	Ethanol content	Fuel	Hot soak + Diurnal	Running Loss
Honda ATV	15-25	65-105 summer	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1
Used ATV	15-25	65-105 summer	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1
		47-66 winter	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1

Number of tests: 9

Appendix C – Emissions Control Technology Testing

Table 6
Testing with the Honda 450X dirt bike *and* Polaris Sportsman 500 ATV

			Test Type			
Fuel Used		Configuration (all fuel levels at 1/2 full)	Running loss	Hot soak	Diurnal	Exhaust
Background Emissions	No Fuel	No fuel, new tank and lines			1	
	CE 10	no fuel in carb.			1	
		no soak			1	
Varying temp/fuel emissions testing	CE10	soaked 30 days, Annual average temp		1	1	
		Refill, Summertime 65-105	3	3	3	
		Refill, Wintertime temp		1	1	
	PH II cert	soaked 30 days, Annual average temp		1	1	
		Refill, Summertime 65-105	1	1	1	3
		Refill, wintertime temp		1	1	
	Summertime pump fuel	soaked 30 days, Annual average temp		1	1	
		Refill, Summertime 65-105	1	1	1	1
		Refill, wintertime temp		1	1	
	Wintertime Pump Fuel (ATV)	Soak 30 Days, wintertime temp		1	1	
Control Technology testing	CE 10	Low Perm Fuel line/tank, soaked 140 days, summertime 65-105	3	3	3	
		Refill, Low Perm Fuel line/tank + passive CC, summertime 65-105	3	3	3	
		Refill, Low Perm Fuel line/tank + Active CC+ FI, summertime 65-105	3	3	3	
Varying temp/fuel control technology testing	CE 10	Refill, All Perm Control, Annual average temp		1	1	
		Refill, all perm control wintertime temp		1	1	
	PH II cert	soaked 30 days, all perm control, Annual average temp		1	1	
		Refill, All Perm control, Summertime 65-105	1	1	1	3
		Refill, All Perm control, Wintertime temp		1	1	
	Summertime pump fuel	all perm control, soaked 30 days, Annual average temp		1	1	
		Refill, all perm control Summertime 65-105	1	1	1	
	Wintertime pump fuel (ATV)	all perm control, soaked 30 days, Wintertime temp		1	1	

Number of Tests: 39 (32 evap. (each for the MC and ATV (70 total) and 4 additional Exhaust)

Appendix D

Table 9
Test Temperature Profiles

Hour	65-105 Temp	Off-road Winter Temp	Annual Average Temp
0	65	47.1	55.3
1	66.6	46.2	54.6
2	72.6	45.6	54
3	80.3	45.2	53.6
4	86.1	44.7	53.2
5	90.6	44.4	53.2
6	94.6	44.1	54.3
7	98.1	44.8	56.8
8	101.2	48.3	60.4
9	103.4	53.5	63.8
10	104.9	58.0	66.5
11	105	61.5	68.6
12	104.2	63.8	70
13	101.1	65.2	70.8
14	95.3	65.8	71.1
15	88.8	65.2	70.6
16	84.4	63.0	68.9
17	80.8	59.3	66.2
18	77.8	55.7	63.2
19	75.3	53.2	60.7
20	72	51.5	59
21	70	50.2	57.8
22	68.2	49.0	56.8
23	66.5	48.4	56

Appendix E

Test Procedure: Exhaust, Hot Soak, and Diurnal

Preconditioning

- Fill fuel system with fuel.
- Operate OHRVs at an idle for 15 minutes.
- OHRVs equipped with low permeation fuel system components will be pre-soaked with fuel in the fuel system for 20 weeks at 30°+/- 10°C*
- OHRVs *not* equipped with low permeation fuel system components will be pre-soaked with fuel in the fuel system for 4 weeks at 30°+/- 10°C*
- After initial soak and for in-use OHRVs the fuel system will be soaked for 4 weeks at 30°+/-10C when fuel type is changed (e.g. E0, E6, E10)

Testing

Running loss/hot soak

- See Appendix F for a complete running loss test procedure

Exahust Emissions testing

- Exhaust emissions testing will be conducted between 68 and 86℉
- The load profile will be the Urban Dynamometer Driving Schedule (UDDS)
- The test procedure will be the same as that used of on-road motorcycles

Diurnal

- Remove the OHRVs from the running loss SHED
- Refill fuel tank to 50%
- **Move the OHRVs into a variable temperature SHED set to 65°F**
- Allow the OHRVs to acclimate for 6* hours or until the Fuel temperature is 65℉ +/- 2℉
- Begin 65°to 105°to 65°F 24 hour diurnal
- Record HC results for the entire profile

*These times may be re-evaluated after preliminary testing.

Appendix F
OHRV Running Loss Test Procedure

Dynamometer Background Emissions

The bearing on the dynamometer will be packed with fluorocarbon grease to limit the possible bias from hydrocarbon grease. Any remaining hydrocarbon emissions from the dynamometer will be evaluated by measuring the temperature of the bearings while a vehicle is put through a UDDS. The dynamometer will then be placed in a SHED and heated in a way to replicate the heat generated during the UDDS test run. The maximum temperature shall be less than or equal to 130℉. This result will be used to compensate for the effects of they dynamo meter in all tests.

Equipment Setup

- The dynamometer will be placed in the SHED and all required connections will be made to control the dynamometer and vehicle remotely.
- The vehicle to be tested will be filled to 50%.
- A thermocouple will be placed in the fuel tank to measure fuel temperature. The vehicle will be placed onto the dynamometer and strapped down.
- Connections will be made to supply fresh air to the carburetor and remove exhaust without affecting the volume of air in the SHED.
- The vehicle will be connected to the throttle control and emergency kill switch.
- A fan will be placed at the front of the equipment and the air speed will be measured at the front of the engine. The air speed shall be fast enough to prevent the engine from overheating and within +/-5mph of the load profile speed.
- The SHED doors will be closed and the SHED will be heated to 105 and held there for 6 hours or until the gasoline temperature is within +/-2℉ degree of the SHED temperature.

Running Loss Test Initiation

During the running loss test the SHED temperature will be 105+/-5℉ maximum and 105+/-2℉ on average When 6 hours have pasted or th e fuel temperature has reached +/-2℉ degrees of the SHED temperature.

1. If the vehicle can be remotely started and placed in gear skip to step 4
2. The tester will enter the SHED in such a way to minimize the amount of air transfer with outside air.
3. The tester will remain in the test chamber for the duration of the running loss test
4. The vehicle will be started, allowed to warm up until the engine will idle without use of the choke, or 5 minutes whichever comes first.
5. The vehicle will be put into first gear and the dynamometer will be brought up to the lowest speed above an idle where the engine can smoothly handle the loads placed on it during the running loss test.

6. The fuel tank heater that will be used to duplicate solar loading will be switched on.
7. The running loss test will begin within 2 minutes of the dynamometer being brought up to speed.
8. The vehicle will be operated on the modified 3 step UDDS running loss test profile defined in the “Engine Loading for Running Loss Emissions” section.

Hot Soak Test

Upon completion of the UDDS load profile the engine, cooling fan, and fuel tank heater will be turned off. Between running loss and hot soak test the tester may leave the SHED. The Hot soak test will have a duration of 90 minutes unless an engineering evaluation of the initial results allow for a 60 minute hot soak test.

All Hot soak testing shall be done in accordance to *Californian Evaporative Emissions Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles* (amended June 22, 2006).